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Geology, Development History, and Exploration Alternatives for Gypsum in the Intervale–Hillgrove Area (Part of NTS 21 H/14), Westmorland County, Southeastern New Brunswick

T.C. Webb

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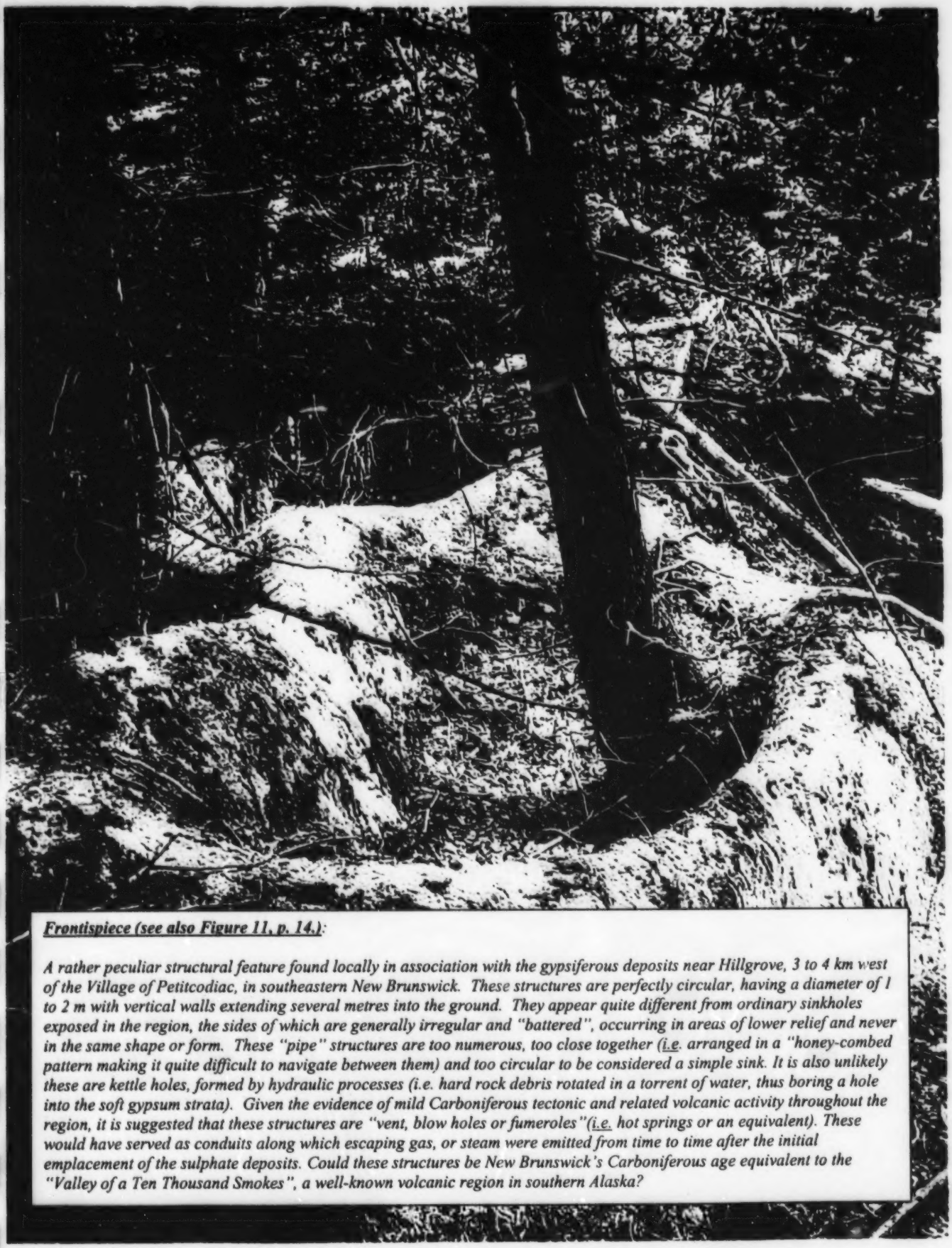

***Frontispiece (see also Figure 11, p. 14.)**:*

A rather peculiar structural feature found locally in association with the gypsiferous deposits near Hillgrove, 3 to 4 km west of the Village of Petitcodiac, in southeastern New Brunswick. These structures are perfectly circular, having a diameter of 1 to 2 m with vertical walls extending several metres into the ground. They appear quite different from ordinary sinkholes exposed in the region, the sides of which are generally irregular and "battered", occurring in areas of lower relief and never in the same shape or form. These "pipe" structures are too numerous, too close together (i.e. arranged in a "honey-combed pattern making it quite difficult to navigate between them) and too circular to be considered a simple sink. It is also unlikely these are kettle holes, formed by hydraulic processes (i.e. hard rock debris rotated in a torrent of water, thus boring a hole into the soft gypsum strata). Given the evidence of mild Carboniferous tectonic and related volcanic activity throughout the region, it is suggested that these structures are "vent, blow holes or fumeroles"(i.e. hot springs or an equivalent). These would have served as conduits along which escaping gas, or steam were emitted from time to time after the initial emplacement of the sulphate deposits. Could these structures be New Brunswick's Carboniferous age equivalent to the "Valley of a Ten Thousand Smokes", a well-known volcanic region in southern Alaska?

ABSTRACT

Near-surface deposits of gypsum ($CaSO_4 \cdot 2H_2O$) occur a few kilometers north and northwest of the Village of Petitcodiac, near the rural communities of Intervale and Hillgrove, Westmorland County, in southeastern New Brunswick.

The sulphate rocks belong to the Lower Carboniferous Upperton and Clover Hill formations, part of a sequence of continental clastics and marine carbonates, sulphates and related chlorides, collectively referred to as the Windsor Group. Deposits of anhydrite and gypsum are generally confined to narrow, steeply dipping bands on the northern flank of the Moncton Subbasin.

Gypsum deposits of the region consist of a 30 to 50 m thick unit of orange brown to white, schistose, alabastrine gypsum (Clover Hill Formation) collapsed on an underlying 150 m thick unit of white massive gypsum and anhydrite (Upperton Formation). This sequence is traceable over a northeast-southwest strike length of 7.5 km. The region's gypsum resource is generally of high quality, commonly exceeding 90% $CaSO_4 \cdot 2H_2O$.

The Intervale-Hillgrove gypsum resource has had a sporadic history of limited production from a quarry site near Glenvale. Although some form of production may have begun here over a century ago, the most prolonged production record is limited to a three-year period during the 1930's and an annual production of up to 25 000 tons reported to have lasted thirty years beginning about 1950.

Considering the Intervale-Hillgrove region's geology and various social and physical constraints to the establishment of a suitable quarry site(s), two areas, one south of Intervale and another northeast of Hillgrove, appear to have unqualified exploration and development potential for gypsum. These areas are speculated to have the capabilities of supporting a small gypsum operation(s) similar to the size of the former quarry at Glenvale.

RÉSUMÉ

Des gîtes subaffleurants de gypse ($CaSO_4 \cdot 2H_2O$) occupent le sous-sol à quelques kilomètres au nord et au nord-ouest du village de Petitcodiac, près des localités rurales d'Intervale et de Hillgrove, comté de Westmorland, dans le Sud-Est du Nouveau-Brunswick.

Les roches de sulfates relèvent des formations du Carbonifère inférieur d'Upperton et de Clover Hill qui font partie d'une séquence de roches clastiques continentales et de carbonates marins, de sulfates et de chlorures connexes, collectivement appelés le groupe de Windsor. Les gîtes d'anhydrite et de gypse sont généralement confinés à des bandes étroites s'inclinant de façon abrupte sur le flanc nord du sous-bassin de Moncton.

Les gîtes de gypse de la région sont constitués d'une unité de 30 à 50 m d'épaisseur de gypse à naphtalène schisteux, de couleur brun orangé à blanc, (Formation de Clover Hill) s'étant effondré sur une unité sous-jacente de 150 m d'épaisseur d'anhydrite et de gypse massif blanc (Formation d'Upperton). On peut retracer cette séquence sur une distance de 7,5 km en direction nord-est-sud-ouest. Les ressources en gypse de la région sont généralement constituées de gypse de haute qualité dépassant communément un taux de 90 % de $CaSO_4 \cdot 2H_2O$.

Les ressources en gypse d'Intervale-Hillgrove ont par le passé sporadiquement fait l'objet d'une production limitée à partir d'une carrière située près de Glenvale. Même si une certaine forme de production est peut-être apparue à cet endroit il y a plus d'un siècle, la période de production la plus longue s'est limitée à un intervalle de trois ans dans les années 30 et à une production annuelle atteignant jusqu'à 25 000 tonnes pendant, rapporte-t-on, une trentaine d'années à partir de 1950.

Compte tenu de la géologie de la région d'Intervale-Hillgrove et des diverses contraintes sociales et physiques présentes face à l'établissement d'une ou de plusieurs carrières convenables, deux secteurs, l'un au sud d'Interval et l'autre au nord-est de Hillgrove, semblent présenter un potentiel favorable à l'exploration et à la mise en valeur du gypse. On pense que ces secteurs pourraient soutenir une ou plusieurs petites exploitations de gypse d'une taille similaire à l'ancienne carrière de Glenvale.

Geology, Development History and Exploration Alternatives for Gypsum in the Intervale-Hillgrove Area, (Part of NTS 21 H/14), Westmorland County, Southeastern New Brunswick

Introduction :

General location: A narrow band of calcium sulphate consisting of a mix of gypsum and anhydrite occurs 3.5 to 6 km northwest of the Village of Petitcodiac near the southwestern part of Westmorland County in southeastern New Brunswick. The sulphate band is approximately 200 to 250 m wide and is traceable over strike length of 8 km between the rural communities of Intervale to the northeast and Hillgrove to the southwest. (Figure 1).

Petitcodiac is adjacent Highway Rte. # 1, about 40 km west of the City of Moncton, near the headwaters of the Petitcodiac River. With a population of a few thousand persons the village serves as a local service center for this part of rural New Brunswick and is well-established as a lumber distribution center. The rural nature of Petitcodiac and its surrounding area is reflected northwest of the village; an area with a long history as a farming district. Dairy and related cattle operations, horse and sheep ranching, tree plantations, and market gardening of vegetable and fruit are all important contributors to the agricultural fabric of the region.

General physical setting and access: Sulphate deposits northwest of Petitcodiac are part of a narrow low northeasterly trending ridge extending from Intervale in the north to Hillgrove in the south. Salt Springs Brook, which flows along the north side of the ridge through an area characterized by broad gently undulating hillside terrain, forms a northern boundary to most of the deposit. An extension of the northeast trending Anagance Ridge (Tingley Hill) provides a confining physical barrier to the south. The south-flowing North River cuts across the sulphate terrain near its northeastern limit. Most of the deposit is confined within elevation 60 meters above sea level.

The area overlying the sulphates is generally comprised of a light to dense (50:50 deciduous / coniferous) forest cover with adjacent areas of open field and pastureland.

With the exception of exposures found at a former quarry site, the sulphate deposit is not well exposed throughout the area. It is traceable indirectly over an 8 km strike length by following a line of dry and wet sinkholes and related depressions between Intervale, Glenvale and Hillgrove.

Most parts of the sulphate terrain are easily accessible from a network of chip-sealed and related gravel roads and trails. The Glenvale road, and Highway Rte.# 890 provide access to the southern

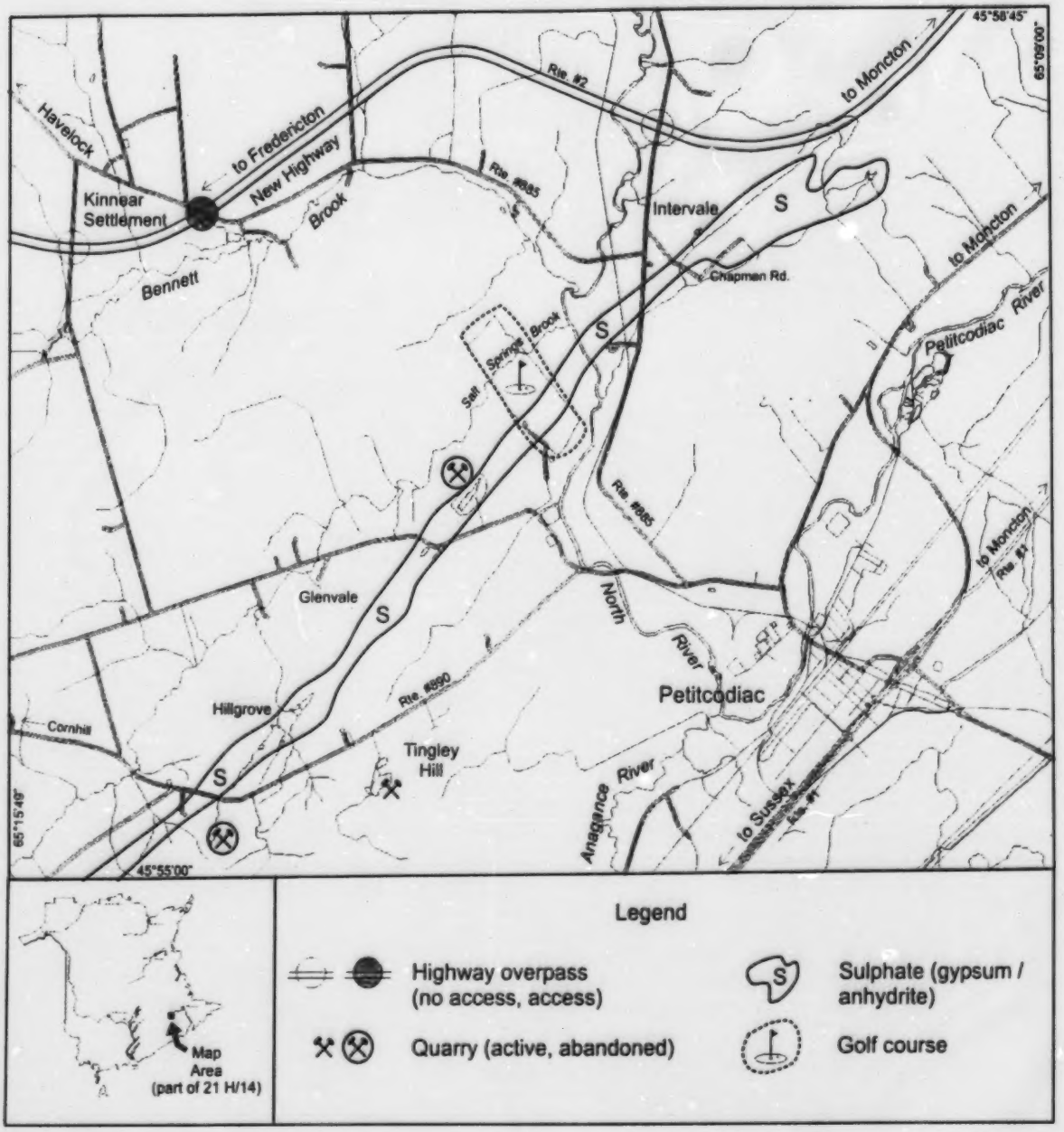

Figure 1. Location, geology and exploration alternatives for gypsum in the Intervale-Hillgrove area, near the Village of Petitcodiac, Westmorland County, southeastern New Brunswick.

portion of the deposit while the Chapman Road connects its northeastern part with Highway Rte. # 885 between Petitcodiac and Havelock. The northeastern part of the deposit is located about 6 km east of an exit-enter interchange (at Kinnear Settlement) to a major four-lane inter-provincial highway system (Rte. # 2) linking the area with other parts of Atlantic Canada and the northeastern United States.

Local landscape features: In general the distribution of the Intervale-Hillgrove calcium sulphate resources is displayed locally through the development of a natural karst. In places, this landscape is typically represented by an irregular to hummocky surface associated with pillars of gypsiferous material with intervening cracks and crevices.

Closed water-filled and sometimes dry depressions, develop where underlying soft gypsiferous bedrock has been dissolved and abraded by circulating ground waters. This often results in the formation of a single or a linear network of subsurface interconnected cavities of various sizes. Eventually the surface expression of these subterranean structures appear as a sink or sinkhole, a result of structural weaknesses in overlying rock and its subsequent collapse into the cavity below forming closed depression. Surface and related ground water may drain through these sinkholes however should the sinks subterranean plumbing system become clogged, they may fill with water forming small lakes and ponds, sometimes referred to as dolines or dolinas

The surface expression of this karst landscape is particularly well developed into a rather rugged terrain between Glenvale and Hillgrove making a ground-based assessment of this area quite challenging.

General land use: Land use in the area underlain by Intervale-Hillgrove gypsum and anhydrite deposits is predominantly agricultural supplemented with several small-scale forest harvesting operations. Recreational activity (*i.e.* golf course) dominates several hectares of the deposit near its northeastern end just west of the North River at Intervale. East of the river is an area of limited forest cover and extensive open cultivated field and pasture land used for agricultural purposes. A few hundred meters southwest of the recreational area gypsum was mined occasionally at small quarry. Operations were curtailed here a few decades ago and the excavation has since been reclaimed. The southwest extension of the deposit is forested and with the exception of very limited forest harvesting, remains virtually undeveloped. Open field and pasture lands immediately adjacent the sulphate terrain support a host of agricultural activities ranging from livestock grazing to silage and hay production.

General Geology :

The geology in the Intervale-Hillgrove area has been studied previously by Stewart (1941), Gussow (1953), Hamilton and Barnett (1970), McCutcheon (1981), and St. Peter (1995).

In general the region is comprised of Carboniferous clastic sedimentary rocks

and related evaporites. These rocks strike to the northeast and dip steeply to the southeast. The distribution of various rock units is controlled by several prominent structural features including northeast-southwest trending thrust faults and several northwest-southeast cross faults.

Detailed Geology :

Geotechnical data from earlier investigations has been compiled along with recent mapping results and is presented in Map Plate 2001-2 (Appendix C), a detailed geology of the Intervale-Hillgrove map area.

The area is underlain by mix of Late Devonian to Upper Carboniferous coarse- to fine-grained sedimentary clastic rocks accompanied by limestone, sodium/calcium sulphates and related evaporites. The oldest rocks belong to the Horton Group (Table 1), a Tournasian-age sequence of fine-grained clastic sedimentary rocks with evaporites in the subsurface. It is best exposed in the northwestern part of the map area where it consists of grey to red, calcareous mudstones and shales with minor carbonate and evaporites [salt and glauberite: ($NaSO_4 \cdot CaSO_4$)] of the Albert Formation overlain by red mudstone, fine-to coarse-grained sandstone and conglomerate of the Weldon Formation. Although Horton rocks typically strike to the northeast and dip 70 to 80° to the southeast, Weldon strata is locally deformed and overturned, dipping steeply (50 to 85°) to the northwest near regional northeast-trending, reverse thrust fault referred to as the "Salt Springs Fault" (St. Peter 1995).

The Salt Springs Fault marks the structural contact between Horton strata to the north and younger Carboniferous rocks of the Windsor Group to the south. Windsor rocks are exposed along a northeast trending ridge, forming a belt of conglomerate, limestone and calcium sulphate up to 500 m wide, traceable over a strike length of 7.5 km. Windsor strata are of Visean age, divided into several formations beginning with the basal Hillsborough clastics succeeded by Macumber, Gays River, and Parleeville carbonates, overlain by Upperton and Clover Hill (calcium) sulphates (Table 1).

The Hillsborough Formation, is not well exposed in the area, however it is speculated to lie adjacent to and south of the Salt Springs Brook Fault. It is exposed south of Glenvale and immediately west of the North River near Intervale where it consists of minor red brown siltstone, fine-to medium-grained sandstone and conglomerate. At this location Hillsborough rocks dip 40° to the southeast, a structural feature that sets this particular redbed sequence apart from lithologically similar strata of the locally deformed and overturned clastics of the Weldon Formation a short distance to the north.

Hillsborough clastics are conformably overlain by carbonates of the Macumber, Gays River and Parleeville formations. These rocks are facies equivalents representing a transition from a basinal (Macumber) to platformal (Gays River) to a shallow, near shore (Parleeville) carbonate depositional setting (Figure 2). Basinal Macumber rocks, typically consisting of dark grey to grey, laminated, intraclastic, wackestone, packstone and minor limestone breccia

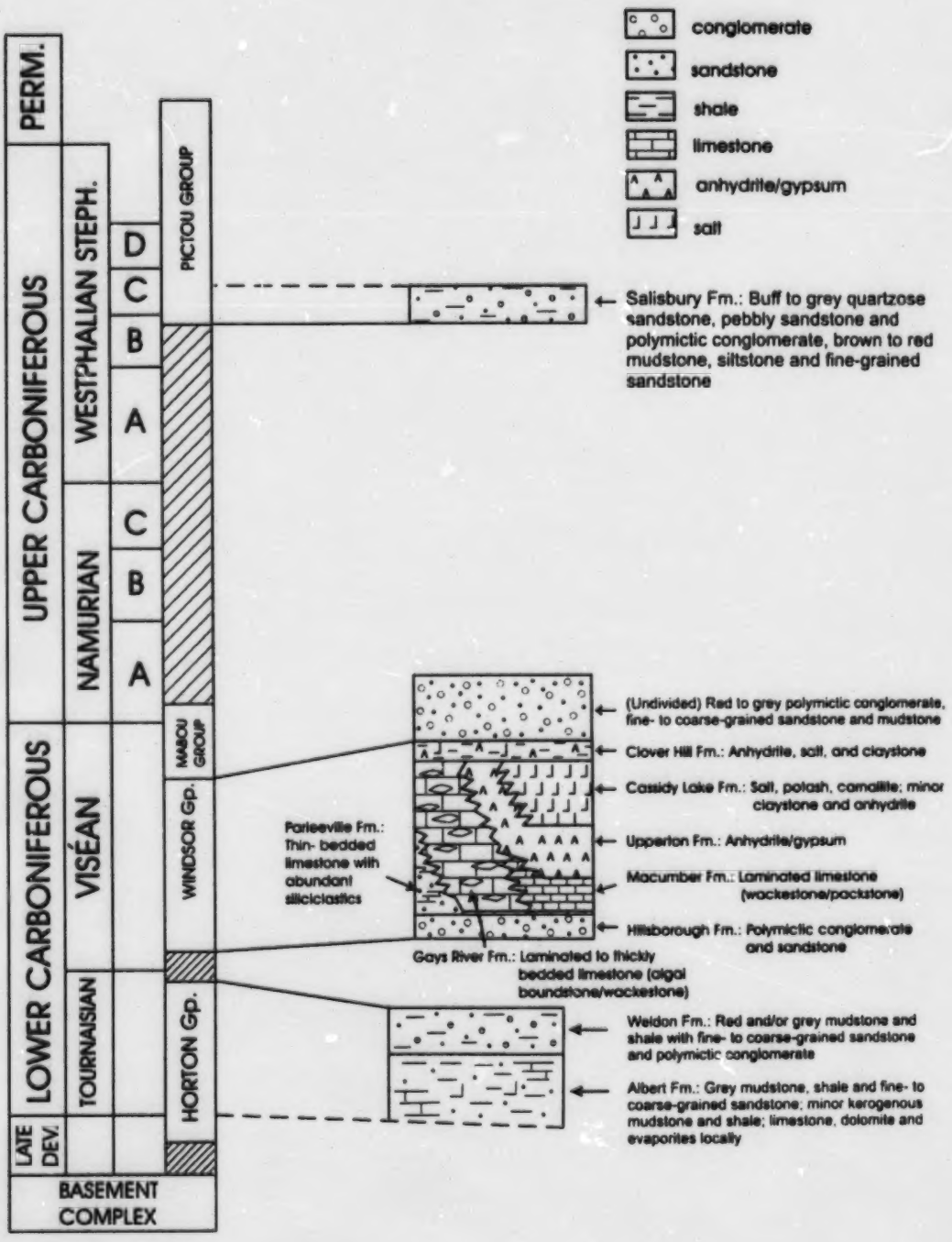
conglomerate
sandstone
shale
limestone
anhydrite/gypsum
salt
PERM.
UPPER CARBONIFEROUS
LOWER CARBONIFEROUS
WESTPHALIAN STEPH.
NAMURIAN
VISÉAN
TOURNAISIAN
LATE DEV.
BASEMENT COMPLEX
D
C
B
A
C
B
A
PICTOU GROUP
MABOU GROUP
WINDSOR Gp.
HORTON Gp.
Salisbury Fm.: Buff to grey quartzose sandstone, pebbly sandstone and polymictic conglomerate, brown to red mudstone, siltstone and fine-grained sandstone
(Undivided) Red to grey polymictic conglomerate, fine- to coarse-grained sandstone and mudstone
Clover Hill Fm.: Anhydrite, salt, and claystone
Cassidy Lake Fm.: Salt, potash, carnallite; minor claystone and anhydrite
Upperton Fm.: Anhydrite/gypsum
Macumber Fm.: Laminated limestone (wackestone/packstone)
Hillsborough Fm.: Polymictic conglomerate and sandstone
Parleeville Fm.: Thin- bedded limestone with abundant siliciclastics
Gays River Fm.: Laminated to thickly bedded limestone (algal boundstone/wackestone)
Weldon Fm.: Red and/or grey mudstone and shale with fine- to coarse-grained sandstone and polymictic conglomerate
Albert Fm.: Grey mudstone, shale and fine- to coarse-grained sandstone; minor kerogenous mudstone and shale; limestone, dolomite and evaporites locally

Table 1. Table of formations for the Intervale-Hillgrove area, near the Village of Petitcodiac, Westmorland County, southeastern New Brunswick (locally suberoded).*

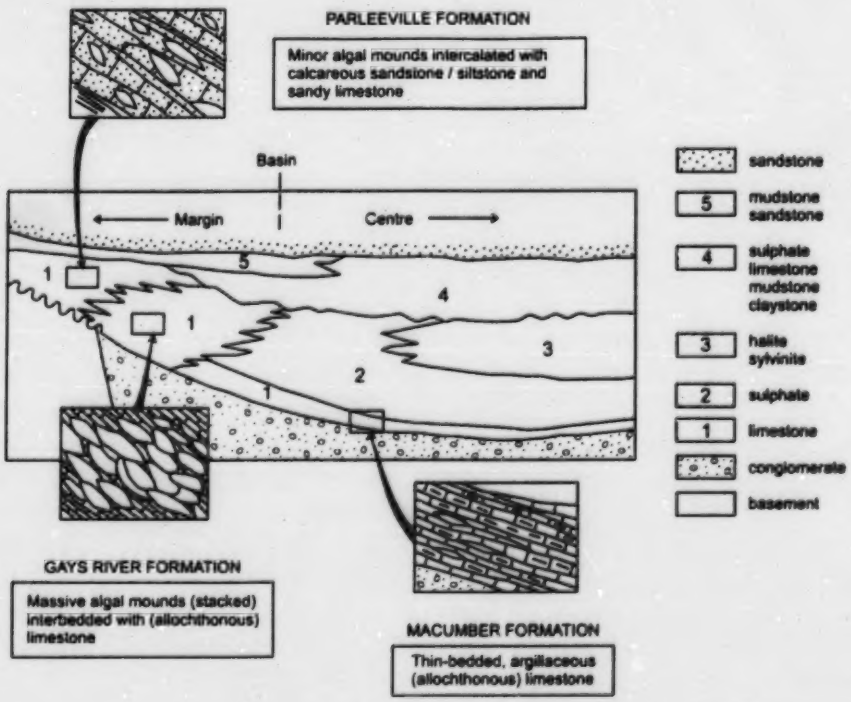

Figure 2. General facies relationships within the Windsor Group, western half of the Moncton Subbasin, south-central New Brunswick

tend to dominant the carbonate strata in the eastern half of the Windsor carbonate belt near Intervale. Windsor carbonates in the western portion of the outcrop belt between Glenvale and Hillgrove, seem to be dominated by thicker-bedded, algal boundstone with minor interbeds of intraclastic wackestone and packstone, typical of the platformal Gays River Formation. Thin-bedded siliciclastic, algal carbonates similar to rocks of the Parleeville Formation described by McCutcheon (1981) on the northern limb of the Case Syncline near Sussex are also found at few locations in the western half of the carbonate belt.

A carbonate breccia composed of blocky, laminated (Macumber Formation?) and massive limestone clasts is also found at a few locations west of Glenvale. The origin of this breccia is uncertain but it may be related to local slumping and movement of partly lithified carbonate in response to mild tectonic (*i.e.* faulting) activity in the region.

Fault structures have affected the distribution of various Windsor carbonate units within the outcrop belt. Relatively abrupt lithologic differences along strike and over short distances are believed to be the result of a north-south trending fault system considered to have developed in response to major thrust faults (*i.e.* Salt Springs and Berry Mills faults) which trend northeastward through the map area (Appendix C).

The calcium sulphate deposits of the Upperton Formation conformably overlie and are intercalated with the upper part of the Macumber and lower part of the Gays River carbonates in the region. The Upperton consists of

mottled, light grey to white, massive to bedded anhydrite that is differentially hydrated to gypsum in most surface outcrops. These rocks are best exposed at the eastern end of a small abandoned quarry near Glenvale (Figure 3).

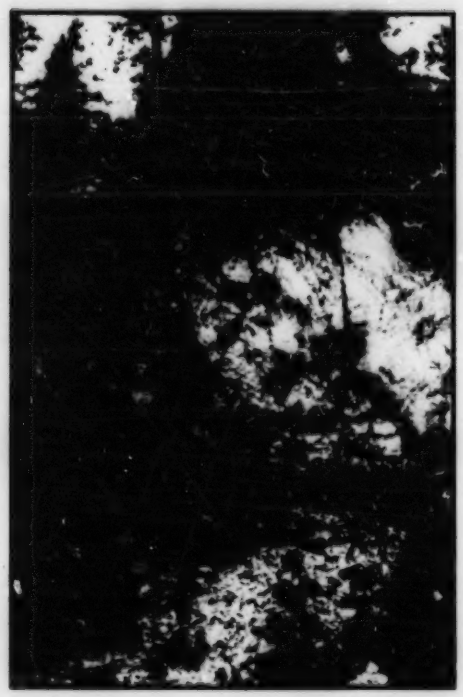

Figure 3. Massive anhydrite / gypsum of the lower sulphate unit (Upperton Formation), exposed at the eastern end of the former Lafarge Canada Inc. quarry at Glenvale, northwest of the Village of Petitcodiac, Westmorland County, southeastern New Brunswick.

Similar to the region's general structural fabric, bedded portions of the deposit strike northeast and dip between 40 and 60° to the southeast. The sulphate unit has a strike width of about 250 m and is traceable several hundred meters.

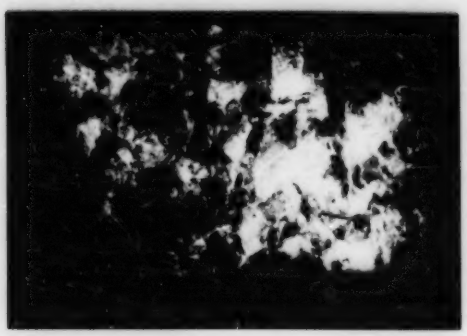

Figure 4. Typical masses of large selenite crystals associated with a fault zone and area of dissolution in the Glenvale quarry, northwest of the Village of Petitcodiac, Westmorland County, southeastern New Brunswick.

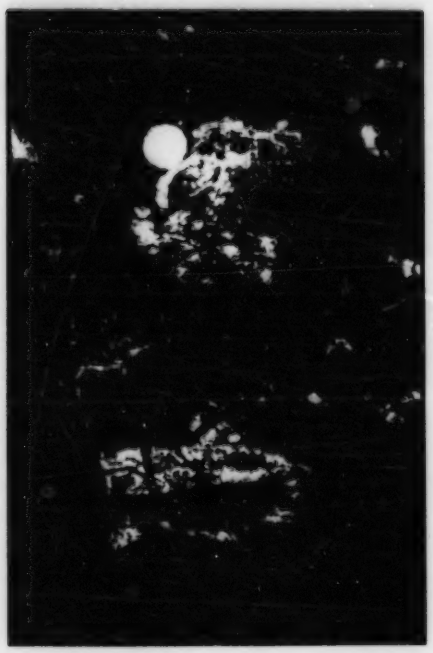

Figure 5. *Chert and grey argillaceous material in a gypsiferous matrix associated with a fault zone and area of dissolution in the Glenvale quarry, northeast of the Village of Petitcodiac, Westmorland County in southeastern New Brunswick.*

A second rather distinctive sulphate unit overlies the Upperton. The contact between the two as seen in the Glenvale quarry is marked by a zone containing variable quantities of coarse crystalline selenite (Figure 4), chert and argillaceous material (Figure 5) in a gypsum matrix. This contact zone, interpreted as a fault, is considered to have been accompanied by some form of hydrothermal activity (*i.e.* presence of chert may be symptomatic of an evaporite deposit influenced by hot springs or some other form of volcanic emanation).

Adjacent and south of this structure is an exposure of white to orange, "schistose" alabastrine gypsum referred to as "sugar rock" due to its distinctive flaky to granulated texture (Figure 6).

Figure 6. Typical granular (i.e. sugar-like" texture) alabastrine gypsum of the upper sulphate unit (the Clover Hill Formation), exposed along the southern limit of the Intervale-Hillgrove sulphate deposits, northwest of the Village of Petitcodiac, Westmorland County, southeastern New Brunswick.

This gypsum contains two different types of selenite crystals: 1) massive, single monoclinic selenite crystals and 2) unusual clusters of selenite forming compact masses of intergrown crystals with thin blades radiating out from a central core (Figure 7).

Figure 7. Spectacular clusters (i.e. rosettes) of stellate gypsum crystals set in defromed alabastrine gypsum, neat Glenvale, northwest of the Village of Petitcodiac, Westmorland County, southeastern New Brunswick.

Clusters, referred to as gypsum rosettes or "flowers" can reach sizes of a few centimeters (in diameter). Their transparent to amber-colored blades, often twinned, protrude contact wall of the outward, producing rather spectacular mineral specimens.
The "sugar rock" gypsum unit dips very steeply to the southeast at 85°; its

schistose fabric reflecting the influence of shearing associated with adjacent fault movement. Further away from the fault zone the unit displays a contorted, bedding style with gypsum and anhydritic layers stretched, thinned and broken into a series of elongated , sausage-shaped fragments (*i.e.* boudins) (Figure 8).

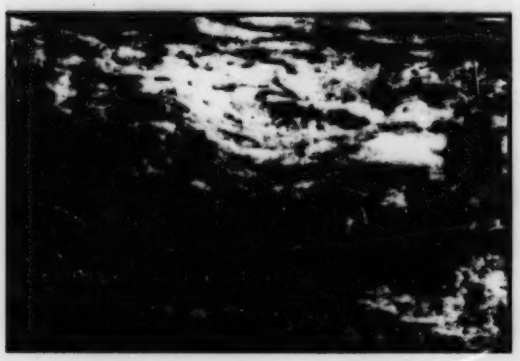

Figure 8. *Contorted bedding and boudins in anhydrite/gypsum strata of the upper sulphate unit (i.e. Clover Hill Formation), exposed along the southern limit of the Intervale-Hillgrove sulphate deposits, northwest of the Village of Petitcodiac, Westmorland Count, southeastern New Brunswick*

The "sugar-rock" and associated gypsum /anhydrite unit parallels the Upperton sulphates along its entire strike length of 7.5 km and can be traced over a strike width of 50 to 100 m. Substantial lithologic and structural differences clearly indicate it to be a separate gypsum unit. It is suggested that this unit may can be correlated with the sulphates and associated claystone of the Clover Hill Formation (Table 1) which up until now was only known from boreholes 30 to 50 km to the west near Sussex.

A combination of faulting, dissolution of underlying Cassidy Lake Formation chlorides (Table 1) and subsequent collapse of the overlying Clover Hill sulphates onto the Upperton sulphates may explain the apparent unconformable relationship between these two gypsum units in the Intervale-Hillgrove area.

The Clover Hill sulphate beds are conformably overlain to the southeast by fine-to coarse-grained clastics of the Mabou Group. Similar to other Lower Carboniferous strata in the map area these rocks strike to the northeast and dip 55-65° to the southeast.

Mabou rocks are intersected by the northeast trending Berry Mills Fault in the southern part of the map area. South of the fault a narrow belt of Mabou stara is overlain unconformably by the fine- to very coarse-grained, quartzose to feldspathic to lithic arenites of the Pictou Group.

Two fault systems affect Carboniferous strata in the map area and are important understanding the regional distribution of various rock units. A series of northeast-southwest trending low angle thrust faults (*i.e.* the Salt Springs Brook and Berry Mills faults) are the most dominant structural features of the immediate area and are traceable over the entire 7.5 km strike length of the Windsor outcrop belt. Associated with these structures are several northwest-southeast-trending smaller-scale secondary normal-type faults that offset parts of the larger regional structures.

Late Visean deformation has had considerable impact on the distribution Windsor strata in the map area. This is reflected in: 1) the local development of

breccia in basal Windsor carbonates, 2) abrupt changes in facies (lithology) across strike, 3) an apparent unconformable contact between the Upperton and Clover Hill sulphates, 4) a schistose fabric in association with drag folds, and 5) recrystallization developed in certain sulphate beds. The impact of this mild tectonic activity was most probably enhanced by the dissolution of Cassidy Lake Formation chlorides and the subsequent collapse of the Clover Hill Formation onto the underlying sulphates of the Upperton Formation.

Calcium sulphate: Gypsum and anhydrite deposits in the Intervale-Hillgrove area are restricted to a 200 to 300 meter-wide zone, traceable over a northeast strike length of 7 to 8 km. The deposit comprises two sulphate units that dip steeply to the south. Both units are well exposed in an abandoned quarry at Glenvale near the northwestern village limit of Petitcodiac and about 500 m west of the Petitcodiac Golf and Country Club. At the quarry, the basal or "lower" sulphate unit, the Upperton Formation, consists of a mottled-light grey to white, massive to bedded anhydrite and gypsum, 150-160 m thick. These sulphates are unconformably overlain by a 20-40 m thick section of greyish-orange, schistose ("sugar-rock"), selenitic, alabastrine gypsum of the upper sulphate unit, the Clover Hill Formation. The contact between the two units is fault zone marked by lenses and masses of coarse-crystalline selenite, a patchy distribution of anhydrite and chert, locally disseminated throughout a gypsiferous sulphate.
Analysis compiled from several (vertical) drill holes (Canada Cement Company Limited 1958) in the vicinity of the former quarry provide a reasonable indication of the subsurface extent and quality of the gypsum resource that can be anticipated throughout the region (Appendix B). In the quarry area gypsum was found to extend to a depth of 60 m ranging from 80 to 99% $CaSO_4 \cdot 2H_2O$ with SiO_2 values between 0.18 and 6.9%.

The gypsum content of the "sugar-rock" and related sulphate generally indicates a relatively high grade material.

Deposit Type :

Calcium sulphate is typically the product of chemical precipitation from saturated brines resulting from evaporation at the air-water interface in marine basinal and related environmental settings. It is suggested that gypsum deposits in the Intervale-Hillgrove area were originally in the form of thick sequences of laminar anhydrite in a deep-water, marine basin setting (Figure 9).

Deeper water environments would have been characterized by elevated salinity and temperature - a setting where a primary gypsum is not stable resulting in its alteration to the more stable mineral form anhydrite.

It appears that the region's gypsum resource is the hydration product (*i.e.* absorption of water molecules into the anhydrite mineral structure) of two separate anhydrite units (*i.e.* an upper one collapsed on a lower one) and subsequent alteration (i.e. anhydrite hydration and recrystallization of gypsum) affecting strata adjacent to and overlying faulted and collapsed sulphate terrain (Figure 10).

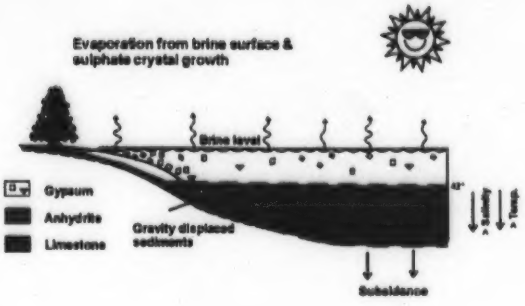

Figure 9. Typical depositional setting for "primary" calcium sulphate deposits.

Exploration and development history:

Among the early accounts of gypsum deposits in the Intervale-Hillgrove area is one presented in Atkinson's, 1843 *"Guide to New Brunswick"*. In the North River area, north of the village of Petitcodiac, gypsum exposures were described as ....*"rising above the marly rocks, in rude, naked columns or broad white masses without any covering of soil or vegetables upon them...."* (Atkinson 1843).

Not much is known about the early attempts to mine these deposits but Bailey and Jack (1880) make mention of some type of gypsum operation existing in the region sometime before 1880. Subsequent revelations in the 1892, Journal of the House of Assembly and by Bailey in 1898 also make reference to the removal of "crude gypsum" from the area for use as a fertilizer (land-plaster).

In 1907 it was reported that the deposit was under the control of the Albert Manufacturing Company, a major supplier of "crude gypsum" and related manufactured plaster products from the

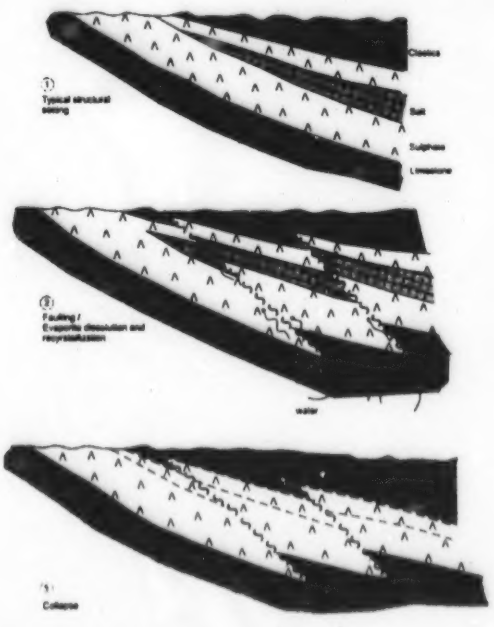

Figure 10. Depositional model for Intervale-Hillgrove sulphate deposits.

Hillsborough area in Albert County (Webb 2001), however there is no record of actual mining activity on the deposit (Ells 1907).

It was not until the later part of 1931 that F.M. Thompson, a former manager of the Albert Manufacturing Company's Hillsborough gypsum operations, established a quarry near Intervale (probably the present Glenvale quarry site). Production was sustained over a three-year period with annual rail shipments of 1100 to 1500 tons *"of good white gypsum"* to the Montreal area (Crown Land Reports 1929 to 1934). Unfortunately the Intervale product was soon to find itself at a competitive disadvantage with cheaper material moved into its primary market area by shipments from other regional sources. This situation eventually forced the enterprise to cease operations by 1935.

Interest in the property was not revived until the early 1950's when the Maritime Cement Company, a subsidiary of Canada Cement Company Limited commenced construction of a cement plant on extensive limestone deposits near the village of Havelock, about 10 km north of the Intervale quarry. The property was obtained by the company as a local source of suitable gypsum, a key ingredient in the cement manufacturing process. Beginning in 1951, Canada Cement, (now called Lafarge Canada Inc.) operated the quarry for 36 years, producing 5 000 to 25 000 tons annually. Operations were curtailed in 1987 following the downsizing and eventual closure the Havelock operation. A reclamation plan involving slope stabilization and revegetation around a pond established in the axial part of the quarry was soon implemented.

By 1996 Lafarge's mineral holdings in the area were reduced thirty-two hectares (*i.e.* two mineral claims) encompassing part of the former quarry and the adjacent area to the west. These are reported to be in good standing until the summer of 2001.

Beginning in the early 1990's several parts of the Intervale-Hillgrove gypsum deposit, peripheral to Lafarge's property, were staked and held for a short period of time by Gordel Investments Ltd. of Saint John. These claims have subsequently expired and have not been renewed.

Despite its long history of sporadic development, the magnitude of accumulated geotechnical data on the Intervale deposit is surprisingly limited. Jennison (1912), Cole (1913), and Hamilton and Barnett (1970) report typical analysis of a few gypsum samples from the area (Appendix A) however, few details are provided as to their exact location. In the vicinity of the former quarry near Glenvale, five holes were drilled by Canada Cement in 1957 and one hole, 300 meters to southwest, was completed in 1998.

Between 1951 and 1987, about 250 000 tonnes of gypsum had been extracted from Lafarge's Glenvale quarry. Total gypsum reserves on the present Lafarge property are reported near 1 300 000 tonnes (Gillis 1998). Other attempts to quantify the Intervale-Hillgrove gypsum resource have been offered by Hamilton and Barnett (1970). Their estimate of 4 000 000 million tons of 97% gypsum was from the Intervale area (most probably an area roughly equivalent to the former Glenvale quarry and immediately adjacent parts of the deposit).

With the exception of the two Lafarge Canada Inc. claims much of the Intervale-Hillgrove gypsum/anhydrite deposit remains open for prospecting and staking (as of March, 2001).

Preliminary Deposit Evaluation :

Exploration alternatives and development potential of the Intervale-Hillgrove gypsum resource appears somewhat limited, reflected in:

- the narrow width and generally steep dipping nature of the gypsum deposit
- high ground water levels in parts of the area between Hillgrove and Glenvale and in parts of the Intervale area (*i.e.* areas of water-filled sink holes) and

- several anticipated restrictions of a social nature (*i.e.* proximity to housing, recreational and active agricultural areas)

Despite these concerns three areas, although unqualified, are considered as reasonable alternatives for exploration and potential development of a small tonnage operation (s). One, thirty-six hectare area (Appendix C) extends 1200 m southwest of where the Glenvale-Baseline Road crosses the deposit to an area of several water-filled sinkholes near Hillgrove. Referred to as Area 1, it features a wet and dry karst landscape, consisting of pillars of gypsum several meters high with intervening cracks and open crevices (generally dry). A rather peculiar landscape feature is one consisting of a interconnected series vertical, perfectly circular holes seen near the south-western limit of the proposed area (Figure 11a). These circular structures have a diameter of 1 to 2 m, with vertical walls extending down to depths of several meters (Figure 11b). They are quite different than ordinary sinkholes. The sides of sinkholes are generally quite irregular and "battered", typically occurring in areas of lower relief, and never in the same shape or form.

These particular structures are too numerous, too close together (*i.e.* arranged in a honey-comb pattern that makes it difficult to walk between them) and too perfectly circular to be considered as simple sink or kettle holes. Nor does it seem likely they have been formed by hydraulic processes (*i.e.* hard rock debris rotated a torrent of water, thus boring a hole in softer gypsiferous material). One possible explanation, supported by apparent mild tectonic and volcanic actvity in the region is that these structures are vents or blow holes for escaping gas or related hydrothermal fluids emitted sometime after sulphate deposition. Even though the walls of these proposed vents are comprised of fibrous gypsum, the fact that they form a honey-comb structure over a considerable area would suggest the harder, more resistant form of sulphate, anhydrite and anhydritic gypsum, may in fact support their characteristic shape and therefore be more prevalent in the area than surface exposures of gypsum would suggest. Therefore, it is probably prudent to core into the sides of these structures to determine the extent of the gypsification process.

Gypsum " sugar rock" (Clover Hill Formation) similar to that exposed in the Glenvale quarry are also well exposed near these structures and are considered to offer high quality gypsiferous material. Although not seen in outcrop the more massive Upperton gypsum deposits are also expected to occur to the north, structurally below the "sugar-rock" material. Attempts to quantify the resource in Area 1 are highly speculative. At this point, assuming no limitations by excessive thickness of overburden, a strike length of 1000 m, an average width of 250 m and a recoverable gypsum thickness of 6 m, an inferred mineral resource of 645 000 tonnes of gypsum is suggested. For the most part, Area 1 occupies wooded terrain and is generally remote from established housing and related human activities.

There remain two other parts of the Intervale-Hillgrove sulphate deposit where potential exploration and development might be considered a

(a)

(b)

Figure 11. *A rather peculiar "honey-comb like" landscape (top) featuring many vertical, smooth-walled structures up to 2m in diameter and 3m deep (bottom) These are interpreted as steam vents, blow holes or fumeroles found in association with gypsiferous deposits near Hillgrove, Westmorland County, southeastern New Brunswick (see also frontispiece)*

possibility. These areas, situated in the Chapman Road area, a few kilometers east of Highway Rte. # 885 at Intervale, feature
80 hectares of open fields and related pastureland with a light forest cover. Much of the area is over 500 m from the nearest housing.

Faulting in this area has resulted in the structural separation of the gypsum resource into two separate bands (cross section A–A', Map Plate 2001-2, Appendix C). The northernmost band, Area 2a is comprised of steeply dipping, schistose to massive gypsum, extending over 20 hectares of active farmland. The gypsum band is less than 125 m wide and is traceable via a series of sinkholes and scattered outcrops along a northeast strike for about 1.5 km northeast of the Chapman Road where the gypsum is overlain (unconformably) by Pictou Group clastics. To the south it is overlain by a narrow band of fine-grained Mabou Group clastics. Sulphate deposits of this area are strikingly similar to those exposed in the old quarry near Glenvale where a schistose, selenitic "sugar-rock" is found overlying a massive anhydrite-gypsum unit. Taking an average recoverable gypsum depth of 6 m, Area 2a may account for an inferred gypsum resource of 580 000 tonnes.

The other gypsum and anhydrite prospect near Intervale, Area 2b, (Appendix C) is less than half a kilometer south of Area 2a. Although not exposed its distribution is inferred on the basis of the area's structural features, (i.e. thrust and related fault structures) it's characteristic landscape (*i.e.* numerous sinkholes) and vegetation (*i.e.*

abundance of cedar trees[1]) common to other areas in the region underlain by sulphate and associated carbonate deposits. Estimated to extend over 30 hectares, Area 2b sulphate resource appears to be more extensive than those of Area 2a to the north. The deposit has an unconfirmed width of 200 m and like Area 2a it is traceable via a line of sink holes for up to 1700 m east of the Chapman Road where it is unconformably overlain by sedimentary clastic cover rocks of the Pictou Group. It is fault-bounded to the north and west by the Berry Mills Fault and a northwest-southeast trending secondary fault structure respectively. To the south it is overlain by fine-grained clastics of the Mabou Group.

Given an average recoverable gypsum thickness of 6 meters, Area 2b may contain an inferred resource over 880 000 tonnes. Area 2b is characterized by active agricultural landbase (80%) and a light forest cover (20%).

In general, the lack of adequate gypsum exposure throughout much of the Intervale-Hillgrove region exploration drilling and related geotechnical work would be required to confirm the presence and true nature of the gypsum resource in any of the areas considered as exploration alternatives.

Conclusions :

The spatial distribution of sedimentary clastics, carbonates and sulphate deposits of the Windsor Group in the Intervale-Hillgrove area, a few kilometers north of the Village of Petitcodiac have been structurally modified by regional northeast-southwest thrust faults.

Recent mapping has revealed two separate calcium sulphate units in the area. These combine to form a gypsum and anhydrite resource exposed in a 200 to 300 m wide belt dipping steeply (50 to 80°) to the south, and traceable over a northeast-southwest strike length of about 7 km.

The lower-most gypsum unit, the Upperton Formation, forms a major part of the deposit. It consists of a mixture of white, massive gypsum and variable amounts of anhydrite, having an apparent thickness of up to 200 m. The grade of the gypsiferous material can vary from about 85-95 % gypsum. The upper gypsum unit, considered equivalent to the Clover Hill Formation, has an apparent thickness of 30-50 m. It is characterized by a distinctive orange brown gypsum with a sugar-like, schistose texture. Two types of selenite crystals are associated with this particular unit ... one single monoclinic type and another, represented by unusual crystal clusters forming rossettes. The Clover Hill gypsum appears to be a higher quality more consistent grade of gypsum, often in excess of 95 %.
A structural break marks the contact between the two sulphate units. This break interpreted as a fault, features coarsely crystalline selenite, with chert and grey clay locally disseminated in a gypsiferous matrix. The sulphate overlying the fault zone bears the evidence of a mild deformational event in the form of a schistose fabric adjacent the proposed fault and contorted bedding and local boudinage structures developed nearby.

[1] In this area tree stands of mature cedar are often found in close association with limestone and related rocks and soils high in calcium.

It would appear that upper sulphate unit (the Clover Hill Formation) and underlying chloride evaporites (Cassidy Lake Formation) may have been thrust over the lower sulphate strata (the Upperton Formation). Following the dissolution of intervening chlorides, the upper sulphate beds may have become saturated with upward moving hot brine resulting in recrystallization of pre-existing sulphate and its subseqent collapse onto the lower sulphate beds. Later hydration flushed the brine out of these rocks imparting their unusual fine-grained granular (*i.e.* sugar-like) texture. Considering the Intervale-Hillgrove region's geology and perceived social and physical impediments affecting the establishment of a suitable quarry site (s), there remain at least three areas that appear to have unqualified exploration and development potential for gypsum. These areas are speculated to have the capabilities of supporting a small tonnage gypsum operation, similar to that undertaken at a former quarry site near Glenvale.

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Bibliography

ANNUAL REPORTS OF THE DEPARTMENT OF LANDS AND MINES (Government of New Brunswick). 1931, p. 38, 1932, p.42; 1933, p, 42; 1934, p. 45

ANONYMOUS (circa. 1977). Intervale gypsum, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, NTS Files, Intervale 21H/14.

ATKINSON, C.W. 1843. A giude to New Brunswick, British North America. Edinborough, Anderson &Bryce, p. 186.

BAILEY , L.W. 1898. The mineral resources of the Province of New Brunswick, Geological Survey of Canada, Summary Report for 1897, Volume 10, Part M, p. 99M.

BROWN, R. 1995. Report of work done : Glenvale Claim Group. Report for Gordel Investments Ltd. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 474667, p. 11.

CANADA CEMENT COMPANY LIMITED. 1958. Plans and maps of gypsum property with quarry and d.d. hole locations, scale 1 inch to 100 feet, (note: provided by D. Clark, Lafarge Canada Inc.). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, NTS Files, Intervale 21H/14.

CANADA CEMENT COMPANY LIMITED. 1958. Gypsum dd core. (note: drill core analysis from 5 holes in vicinity of Glenvale quarry provided by D. Clark, Lafarge Canada Inc.). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, NTS Files, Intervale 21H/14.

COLE, L.H. 1913. Gypsum in Canada: its occurrence, exploration and technology. Canada Department of Mines, Mines Branch, No. 245, p. 45.

COLE, L.H. 1930. The gypsum industry of Canada. Canada Department of Mines, Mines Branch, No. 714, p. 34.

ELLS, R.W. 1907. The geology and mineral resources of New Brunswick, Canada Department of Mines, Geological Surveys Branch, No. 983, p. 122.

GESNER, A. 1840. Second report on the Geological Survey of New Brunswick. Saint John, p. 45.

GESNER, A. 1841. Third report on the Geological Survey of New Brunswick. Saint John, p. 39.

GILLIS, M.X. 1998. Diamond drilling program, 1998: Glenvale Claims, New Brunswick. Report for Lafarge Canada Inc. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Assessment File 475080, p.7.

GOODWIN, D. Sc. 1928. Geology and minerals of New Brunswick. Industrial and Educational Publishing Co., Gardenvale, Quebec, p. 50.

HAMILTON, J.B. and BARNETT, D. E. 1970. Gypsum in New Brunswick. New Brunswick Department of Natural Resources, Mineral Resources Branch, Report of Investigation 10, pp. 22-31.

JENNISON, W.F. 1911. Report on gypsum deposits of the Maritime Provinces. Canada Department of Mines, Mines Branch, pp. 150-151.

JOURNAL OF THE HOUSE OF ASSEMBLY (NEW BRUNSWICK), 1892, P. C-5.

KRAMM, H.E. 1912. Gypsum of New Brunswick. Canada Department of Mines, Geological Survey Branch, Summary Report for 1911, pp. 324.

McCUTCHEON, S.R. (1981) Geology maps; Intervale area, (21H/14). Scale 1 inch equals ½ mile, New Brunswick Department of Natural Resources, Mineral Resources Division, Map Plate 81-90.

MITCHELL, B. 1999. Glenvale gypsum deposit, Mineral Claims Group 11-1190 (326831-326832): 15 year technical report. Report for Lafarge Canada Inc. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Mineral Exploration Report of Work, Progress Report 15-012, p.6.

ST. PETER, C. 1989. Horton Group lithofacies and generalized geology of the Moncton Subbasin: western part, (parts of 21H/11, 12, 13, 14; 21I/3, 4), Scale 1:75 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 89-101.

ST. PETER, C. 1989. Geology of the Albert Formation, Moncton Subbasin, Sheet K, (parts of 21H/14 and 21I/3). Scale 1:20 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 89-104K.

ST. PETER, C. (1990). Simpified geology map of southeastern New Brunswick showing major faults that displace Upper Devonian and younger rocks, (NTS 21H/10,11,14,15; parts of 21H/12,13,16; 21I/1,2,3,4). Scale 1:250 000, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 92-33.

ST. PETER, C. 1995. Bedrock geology of the Petitcodiac-Intervale area (21H/14f). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 95-22A

ST. PETER, C. 1995. Bedrock geology of Havelock/Cornhill-Intervale area (21H/14g). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Map Plate 95-22B.

STEWART, J.S. 1941. Geology of Petitcodiac (east half), Kings, Westmorland and Albert counties, New Brunswick. Geological Survey of Canada, Map 642A (with marginal notes).

STEWART, J.S. 1941. Geology of Petitcodiac (west half), Kings, Westmorland and Albert counties, New Brunswick. Geological Survey of Canada, Map 643A (with marginal notes).

SUND, J.O. 1958. Origin of New Brunswick gypsum deposits. Unpublished MSc thesis, University of New Brunswick, Fredericton, N.B. pp. 86-94.

SUND, J.O. 1959. Origin of New Brunswick gypsum deposits. Canadian Institute of Mining and Metallurgy Transactions 62, pp. 395-400; and Canadian Institute of Mining and Metallurgy Bulletin 571, pp. 707-712.

THOMAS, L.O. 1930. The Province of New Brunswick, Canada: Its natural resources and development. Department of the Interior, Ottawa, Canada, p. 93.

WEBB, T.C. 1977. Gypsum and related deposits of New Brunswick. New Brunswick Department of Natural Resources, Mineral Resources Branch, Topical Report 77-6, pp. 25-26.

WEBB, T.C. 1997. Carboniferous limestones of New Brunswick: geology and development potential. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 97-6, pp. 82-84.

WEBB, T.C. 2001. Geology, development history, and exploration alternatives for gypsum and anhydrite resources near Hillsborough (part of NTS 21 H/15), Albert County, southeastern New Brunswick. New Brunswick Department of Natural Resources and Energy, Geological Surveys Branch, Minerals and Energy Division, Open File Report 2001-6, 47 p.

APPENDIX A

Table of compiled chemical analysis of gypsum samples from the Intervale-Hillgrove area 3.5 to 6.0 kilometers northwest of the Village of Petitcodiac, Westmorland County, southeastern, New Brunswick (1911and 1970)

APPENDIX B

Table of chemical analysis of gypsum/anhydrite from drill holes from the Glenvale (Intervale-Hillgrove) area, 3.5 kilometers northwest of the Village of Petitcodiac, Westmorland County, southeastern, New Brunswick

Appendix A. Table of compiled chemical analysis of gypsum samples from the Intervale-Hillgrove area 3.5 to 6.0 km northwest of the Village of Petitcodiac, Westmorland County, southeastern, New Brunswick (1911and 1970). *Note: sample sites unknown / c = calculated*

	Wt %											
Source	Insol.	Fe_2O_3	SiO_2	Al_2O_3	CaO	MgO	SO_4	H_2O	$CaCO_3$[c]	Total	$CaSO_4 \cdot 2H_2O$	$CaSO_4$
Jennison, (1911)	0.32	-	-	0.14	32.48	tr.	46.55	20.48	-	99.79	97.86	1.65
Cole (1930)	0.21	0.11	-	0.03	32.48	0.08	46.50	20.30	-	100.06	97.00	2.63
Hamilton and Barnett (1970)	-	0.10	0.57	0.57	34.63	<0.01	44.60 (SO_3)	16.00	4.85	98.22	62.44[c]	26.46[c]

Appendix B. Table of chemical analysis of gypsum/anhydrite from drill holes from the Glenvale (Intervale-Hillgrove) area, 3.5 km northwest of the Village of Petitcodiac, Westmorland County, southeastern, New Brunswick. (Canada Cement Company Limited 1957; provided by D. Clark, Lafarge Canada Inc. and Gillis 1998) (Map Plate 2001-2, Appendix C for location) *Note: c = calculated*

Drill Hole #	Core Interval Sampled (meters)	$\%SiO_2$	$\%R_2O_3$	%CaO	%MgO	$\%SO_3$	% LOI	%Total	$\%CaSO_4 \cdot 2H_2O^C$	$\%CaSO_4{}^C$
57-1[1]	0 - 15	0.24	0.22	32.51	0.09	45.72	20.92	99.70	99.15	-
	15-30	0.18	0.14	32.60	0.14	45.34	20.78	99.68	97.90	-
57-2	0-15	0.50	0.28	32.78	0.13	44.65	21.46	99.80	98.81	-
57-3	0-15	6.90	2.46	30.15	0.54	40.37	19.88	100.30	87.71	-
	15-30	5.64	1.70	31.42	0.25	42.97	17.88	99.76	82.30	7.99
57-4	0-15	9.30	2.24	30.26	0.34	36.34	20.58	99.06	81.06	-
	15-30	12.16	2.32	29.72	0.38	34.34	20.38	99.30	76.56	-
	30-45	16.58	3.32	28.27	0.46	28.56	19.88	97.07	63.83	-
	45-60	21.12	3.12	27.18	0.30	25.77	19.48	96.97	53.43	-
57-5	0-15	2.22	1.04	36.40	0.34	39.35	19.40	98.95	60.67	18.94
	15-30	2.46	1.20	40.68	0.38	45.48	8.62	98.82	9.2	70.1
GL 98-01[2]	9.4 -11.1 (1.7)	1.79	0.61	29.37	0.09	44.84	21.45	98.15	92.20	3.26
	19.8-21.0 (1.2)	2.03	0.54	28.77	0.10	45.30	20.49	97.12	84.31	10.36

1. Canada Cement Company Limited, 1957 and 2. Lafarge Canada Inc., 1998

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APPENDIX C

Map Plate 2001-2. Carboniferous geology and gypsum resources of the Intervale-Hillgrove area (part of NTS 21H/14), Westmorland County, southeastern New Brunswick